ORANJEMUND SHIPWRECK: A COMPOSITION ANALYSIS OF THE PEWTER KITCHEN WARE AND THEIR CONSERVATION ASPECTS.

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DECLARATION OF ORIGINALITY

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Contents

Figures

Tables

Chapter 1

Introduction

1.1 Background of the study

The old saying goes: “History rarely unfolds like a fable”. But imagine this: A sixteenth century Portuguese trading vessel, carrying a fortune of treasure, destined for the famous spice Islands on the coast of India is likely blown off course by the heavy storms while trying to round the Cape Cross (Smith 2009:2).

Having left Portugal sometime in the second quarter of the sixteenth century, this ship was loaded with valuables, merchandise to trade and weapons to defend themselves against pirates, particularly the Spanish - who were known for robbing the Portuguese of their valuables during this period (Nakale unpublished report). Little did they know that their fate was about to change when their ship is believed to have hit a very big rock on the skeleton coast near modern Oranjemund, a town in southern Namibia. The aggressive sea gave a home to the shipwreck and preserved it for more than 500 years until diamond mining activities revealed the treasure to the entire world (Chirikure, Sinamai, Goagoses, Mubusisi, & Ndoro 2010).

In April of 2008, during a mining session in Oranjemund, Kaapanda Shatika (Namibian government and De Beers Group), an employee at Namdeb unearthed a shipwreck. He stumbled upon several artefacts such as wood, copper ingots, two cannons and some pewter objects lying on the seabed in the mining area of U60 (Mowa, Nkengbeza and Kangumu 2018:49). His discovery was unique in the history of diamond mining in Namibia. Subsequently, more artefacts were encountered nearby and these included the following: 32 elephant tusks, 5 anchors, lead sheeting, bronze swivel guns and wood. There were also tin ingots, navigational equipment, as well as a brass mortar and pestle (Chirikure et al. 2010:32).

After a systematic excavation, the Oranjemund shipwreck produced a remarkable range of 5438 archaeological artefacts and is the oldest and richest wreck ever discovered in Sub–Saharan Africa. Gold and silver coins, ivory, kitchen utensils, food residues, navigational instruments, metal ingots and part of the structure of the ship were recovered. Among the discoveries, the gold coins attracted the most attention. (Chirikure et al. 2010; Knabe & Noli 2012: 153).

This study was born out of the interest of this amazing discovery and it will focus on the conservation aspects of kitchen utensils - mainly the pewter plates. The pewter assemblage at the Oranjemund Shipwreck Collection consists of a total of eighty-three (83) objects. Among these are: fifty-one (51) plates, four (4) trays and twenty-eight (28) jugs with lids and handles.

In order to conserve the artefacts, one needs to know the composition of the pewter alloys used. This study will examine the corrosion of the items and do a composition analysis of historical pewter to come up with best preservation practices, as well as preventive conservation measures. Preventive conservation refers to the preventive care practices that avert damage and deterioration of these unique objects. This process involves research, observation, environmental monitoring, documentation and proper housekeeping because the environment plays a major role in the preservation and conservation of objects recovered from the sea. Leaded pewter can be resistant to corrosion of seawater, but once it is exposed to different temperatures, relative humidity and oxygen, deterioration occurs (Carlin and Keith 1997:66).

1.2 Statement of the problem

The existing conservation literature for Maritime Conservation in Namibia is only based on the Oranjemund shipwreck. So far, substantial literature concerning the conservation of objects found on the Oranjemund shipwreck mainly exists in the form of reports such as: Maritime Archaeology and Trans-Oceanic Trade (Chirikure 2010), Assessment of New Storage Facilities for Shipwreck Artifacts (Sinamai 2009), Rescue Excavations at Oranjemund (Werz 2009), Oranjemund shipwreck ivory: a historical analysis on the prospective geographic origin (Mowa et al 2018) and The Shipwreck of Bom Jesus, AD 1533: Fugger Copper in Namibia (Hauptman 2016).

The conservation and compositional analysis of pewter artefacts has not been studied yet. Despite the high prominence given to the Oranjemund Shipwreck, the project is still under-resourced. Since the rescue of the Bom Jesus in 2008, the pewter artefacts from this wreck, described by many as one of that era's most important finds, remain hidden. The artefacts are stored in a dimly lit warehouse, with most of them accumulating dust and are accessible to a few privileged visitors and mine workers who have to pass through Namdeb's security checkpoints (Torchia not dated).

That is why this study focuses on assessing and investigating the condition and possible conservation treatments of the pewter objects (mostly plates) that form part of the Oranjemund collection. It is important to note that many of these pewter objects are currently in various stages of corrosion and deformation.

1.3 Research Objectives

The main objective of this study was to assess and investigate the condition and possible conservation treatment of the pewter objects at the Oranjemund Shipwreck Collection.

The specific objectives were:

1.3.1 To investigate the chemical composition and alloy characteristics of the pewter plates.

1.3.2 To assess the conservation conditions of the pewter kitchen ware. (i.e., *current storage and environment)*.

1.3.3 To analyse the corrosion products of the pewter plates.

1.3.4 To make recommendations for the effective preservation, restoration and conservation of the pewter objects.

1.4 Research Questions

The main research question of this study was: What are the best conservation methods for pewter artefacts recovered from marine environment?

The secondary research questions were:

1.4.1 Are there any similarities between the compositions of the objects?

1.4.2 What is the appropriate storage environment for marine recovered pewter plates?

1.4.3 Is the composition of the alloys of these plates typical of sixteenth century pewter?

1.5 Significance of the study

As far as I am aware, no study has been done on the compositional analysis and conservation of pewter objects in Namibia. The remains of the ship once owned by the Portuguese King Joao III, and identified as the Bom Jesus by archaeologists, are under serious conservation threat (Torchia not dated). The rate at which deterioration is taking place is rapidly increasing and this is worrisome to many archaeologists and historians. The opportunity for valuable research and heritage tourism in Oranjemund may be missed, as decay gradually takes its toll on these finds (Torchia not dated). The case study of the Oranjemund shipwreck will serve not only to contribute to the existing body of knowledge on preservation and conservation of underwater cultural heritage, but also help to raise awareness of the best and most effective measures to ensure successful restoration and conservation of pewter objects.

1.6 Delimitations of the study

The study was limited to the Oranjemund Shipwreck as a case study with a purposefully selected sample and was not generalized. The focus of this study was on assessing and investigating the conditions and possible conservation treatments of the pewter objects at the Oranjemund Shipwreck Collection only, rather than examining technical issues involved in the preservation of marine archaeological objects as a whole.

1.7 Literature review and Theoretical Framework

1.7.1 Literature review

No literature on Pewter conservation and composition analysis was identified in the Namibian context.

However, historical pewter has been examined elsewhere in the world. Different researchers have done their studies in the context of their respective countries. Some have reported on the investigation of Pewter alloy by having a sample of typical objects analysed by ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometry), as well as look at their form and usage (Weinstein 2011). Some have tackled the classification and identification of lead pewter objects (Sutton 1998), while others have researched the composition analysis and dating of pewter ingots (McDonnel 1988). Brownsword and Pitt (1984) did a XRF analysis of 13th-16th century English pewter flatware to determine the nature of the alloys used by the pewterers in the thirteenth to sixteenth centuries. Their findings were then compared to data from literary sources of that period. Scholars like Ronald (1994) described the recovery of plates and a porringer on a beach in south-west England and explained the subsequent conservation techniques employed. Marks from makers and owners support a French origin for the pewter from this collection.

In Namibia, on the other hand, most researchers in the area of underwater cultural heritage have focussed their studies on preventive conservation report. However, Hauptmann (2016) did a similar study on copper ingots recovered from the Oranjemund shipwreck. The author investigated the challenges and opportunities of underwater cultural heritage in Namibia (Nakale unpublished report) and did an assessment of new storage facilities available for shipwreck artefacts in Oranjemund (Sinamai 2009). Their findings and conclusions are, however, limited mostly to shortcomings and challenges. This left room for further investigating the most suitable conservation and restoration practices for pewter plates.

1.7.2 Theoretical framework

This study is situated within the framework of safeguarding and preserving underwater cultural heritage as set out at the UNESCO 2001 convention. Underwater cultural heritage can be defined as human existing activities with historical, cultural or archaeological significance regarding objects that have been submerged or been partially in water for more than hundred years (Maarleveld et al 2013). These sites open up new windows into our past and give us a great understanding of both local and international history.

The UNESCO 2001 convention further states that the significance of underwater heritage such as shipwrecks, submerged cities and harbours is mostly taken for granted. Deterioration, looting and illicit trafficking are some of the major threats to underwater cultural heritage that consequently deprives humanity of their heritage. The ocean and waves have protected and preserved many wrecks and ruins for centuries, but the advancement in diving techniques made these sites more accessible to people (including the treasure hunters) putting them at high risk (Khakzad 2008). This study generated results which led to recommendations that can be used by the National Museum of Namibia to develop a strategy or road map for potential improvements in the conservation and preservation of marine recovered metal objects.

1.8 Research Methodology

Research methodology is defined by Maxwell (2012) as a research strategy and an empirical enquiry that investigates a phenomenon within its real-life context. This study made use of both quantitative and qualitative research methods, as this was deemed to be the most appropriate approach for this study. Mixed methods allowed the researcher to derive and present brief information and conclusions from the complex issues of pewter conservation and composition analysis.

This study collected data through interviews, observation and X-ray Fluorescence (XRF). The technical staff of the underwater archaeology department at the National Museum of Namibia was interviewed, as they are responsible for the physical preservation and handling of the pewter objects. Observed, among others, were storage facilities, availability of environmental monitoring systems and general housekeeping. Non – invasive analysis was done on a limited sample of pewter objects with X–ray Fluorescence spectroscopy.

This study made use of non-probability sampling techniques and used a semi-structured interview guide, an observation checklist and an XRF as research instruments. The key mechanism used in ensuring reliability and validity includes the use of multiple methods of data collection and the comparison of data collected through those methods. The researcher wrote a letter with detailed information about the proposed study to the director of the National Museum of Namibia, to seek permission to carry out the proposed study. Written permission was then granted. The researcher then sent consent letters to the individuals that were interviewed and waited until they were signed. Only then could the researcher start with the interviews, which were conducted in the participants' respective offices.

The researcher then travelled to Oranjemund, accompanied by Ms Loubser, with an XRF spectrometer do the compositional analysis on the selected samples. The data collected through this mixed method study was analysed, applying the mixed analysis method and then presented through descriptive narrative and illustrations.

1.9 Research Ethics

To protect the human rights and ethical values of the participants who have partaken in this study, there were set guidelines. The researcher obtained ethical clearance from the University of Pretoria's (UP) Ethical Committee. The data collected was used only for the purpose of this study. Recordings will be stored in a computer with restricted access and notes were stored securely and anonymously. The identities and other personal information of participants were handled with complete anonymity. In addition, all participants participated voluntarily and no one was in any way forced to participate. They were allowed to withdraw at any time with no negative consequences. The researcher gained permission to record the interviews, with note taking as an alternative in case a participant did not want to be recorded.

2.0 Chapter summary

This chapter outlines the research methodologies employed by this study, describing how the data was collected and analysed. It also focuses on the research questions of this study and explains its significance. The next chapter reviews literature and discusses the conceptual framework.

Chapter 2

Literature Review and Theoretical Framework

2.1 Introduction

The preceding chapter defined the focus of the study by outlining the introduction to the study, research aims and objectives, significance of study, justification and theoretical framework for the study and the research methodology. This chapter presents literature on the history of pewter, its manufacturing and usage, its composition and its conservation. These aspects are broken down further, into sub themes, for a detailed explanation and better understanding. The next sub section focuses on the history of pewter.

2.2 History of pewter

Pewter is an alloy that has tin and lead as its main element. Its composition sometimes consists of other minerals such as antimony, copper and iron. Silver can accidently form part of pewter's composition as well. Pewter was very useful in both ecclesiastical and domestic furnishings during the centuries of living art and that's why it has made its way through to museum collections in the modern world (RTN 1916:231). Historically, pewter was well known in the Greek and Romans empires, as it was widely used. The Chinese were experts in manufacturing it until the Europeans rose from the dark ages and developed the Guild Ordinance in 1348. In America, before 1750, pewter remained a ware for the wealthy only, with many households using woodenware. It was every housewife's dream to see pewter ware in her kitchen or living room. The Egyptians worked pewter as early as 1300 BC - this has been proven by the artefacts recovered from ancient tombs in Egypt (Witkowski 1993:28).

The Guild Ordinance was an organization for pewterers that controlled the manufacturing and trading of pewter in London (Kerfoot 1924:11). This company had been in existence and operated for many years and was allowed to control all pewter brought in London and defined pewter in three different alloys. They even confiscated any pewter that didn't meet their standards. The three alloys that were recognized by the pewterer's guild are: Fine pewter (which should be lead free and was mostly produced for plates and dishes), Trifle alloy (which was allowed to have at least up to 4% lead - this was used for hollow-ware like pots or containers) and Lay pewter (where the percentage of lead allowed is not clearly defined). Lay pewter was notably not to be used for cutlery and drinking vessels (Ströbele and Schuster2019:3).

2.3 Production and Usage of pewter

Pewter was mainly produced through alloying-alloys which are produced in iron pots. Usually tin is added first, both because it is the largest component of the alloy and because it has a relatively low melting point at 232 °C. Alloys must be mixed thoroughly while molten and for reproducibility both exact temperatures and masses of materials are recorded. Since the production is a batch process, the newly alloyed pewter is cast into ingots and allowed to cool, rolled and spun. This is the process whereby the flat piece of pewter is lathed into a desired form or shape and soldering, turning and hammering techniques are employed, using bronze moulds, lathe and soldering irons (De Gruyter, 2016). Tin was hardened with copper to produce a good working alloy because it was too soft for normal casting (Weinstein 2011: 44).

Different metals were mixed for flatware and hollowware, which are melted in iron vats over a forge fire before being ladled into the required moulds. Tin melts at a very low temperature, compared to copper. Weinstein (2011:44) further explains that copper in tin forms a compound because it is insoluble. This explains the high percentage of copper found in some pewter ware. Lead was also used to improve and harden the durability of tin and was mostly added to hollowware. Bismuth only appeared in pewter ware from the sixteenth century onwards. Many pewter items were engraved with owner or producer’s marker, coat of arms or commemorative dates.

2.3.1 Usage

During the medieval period, many pewterers manufactured a variety of pewter vessels that range from domestic to ecclesiastical use, such as flatware (platters, dishes and saucers) and hollowware (flagons, ewers, tankards, water pitchers and candlesticks). Pewter ware dominated the twelfth century as domestic tableware and by the sixteenth century wooden ware and pottery was being replaced by pewter vessels. At the peak of its fame (during the late 1700’s) pewter become something of a status symbol and was bequeathed by will.

However, by the eighteenth-century, pewter itself was being replaced by ceramics and only remained useful for taverns and medical use (Weinstein 2011: 49). As indicated earlier, pewter came in different grades and London’s pewter was considered to be the finest in the world. It was used in almost every household in England, while Roman pewter had more lead and was considered unhealthy (especially for food consumption vessels) (Witkowski 1993:28).

In churches pewter came in the form of Baptismal basins and beakers. Many communion tokens used in churches were made out of pewter as well. It is also worth noting that pewterers never produced items for business purposes, and if they did, these items didn’t survive any archaeological records. They were also not preserved by pewter collectors.

The pewter industry started collapsing by the early nineteenth century, although it didn’t entirely disappear. Today pewter is used for decorative purposes in order to bring back the feel and memories of the past (Witkowski 1993:34).

2.4 Conservation of Pewter

The conservation of metallic archaeological artefacts is a challenge, regardless whether they are ancient or from the recent past. The conservation of artefacts has a long history, but professional conservation is dated back to the 1950's and was founded by the International Institute for the Conservation of Museum Objects conservation (Pearson 2014).

Conservation is defined as the procedures taken to preserve and prolong heritage objects for posterity and ensures that there are secure and stable cultural records for future generations. Conservators achieve all this through the actions of preservation, remedial conservation and restoration. These activities are framed by professional codes of ethics that describe conservation philosophy and practices (Sloggett 2018:1). Dillmann et al (2013) looked at the analytical techniques used for measuring and analysing corrosion processes, including time resolved Spectro electrochemistry, voltammetry and laser induced breakdown spectroscopy.

2.4.1 Preventive Conservation

Preventive conservation refers to the preventive care practices employed that prevent damage and deterioration of these unique objects. This process involves research, observation, environmental monitoring, documentation and proper housekeeping, because the environment plays a major role in the conservation of objects rescued from a marine environment. Leaded pewter can be resistant to the corrosion of sea water, but once it is exposed to different temperatures, relative humidity and oxygen, deterioration occurs (Carlin and Keith 1997:66).

2.4.2 Interventive Conservation

The conservation of pewter can be divided into both interventive and preventive techniques. Interventive conservation mostly involves adding or removing something from the objects itself, such as corrosion products, in order to preserve it. It also involves physically interfering with the object to restore it, for example straightening a deformed pewter plate. Preventive techniques aim to prevent further corrosion and deterioration on the treated artefacts through controlling the environment, as mentioned above.

Both approaches require a good understanding of the physical and chemical composition of the metals, their interaction with environmental variables and the properties of their corrosion (Watkinson 2010:3309).

2.4.3 Interventive Conservation Techniques for Pewter Objects

Conservators are always confronted with challenges when it comes to preserving archaeological materials recovered from marine environment. There are several techniques developed to preserve pewter objects and the choice of which technique to use lies with the individual conservator. As stated above, the conservator should be aware of the corrosion products of an object (which is the results of exposure to different environments) before applying any conservation techniques.

Hamilton (1999:85) noted that pewter objects' corrosion products are more stable once removed from the sea. The corrosion products might be seen as disfiguring the object, but it hardly causes any chemical reaction that might further destroy the reaming of the object. He further stated that pewter objects should be cleaned for aesthetic reasons and to expose the possible archaeological evidence that might be hidden under the corrosion. Old pewter, which is an alloy of tin and lead, should be treated like tin because it's more chemically sensitive. Acids or sodium hydroxide can be very harmful to the objects and should be avoided when cleaning it.

North (1987:207) wrote that the first technique in pewter conservation is removing the concretion, because many metal objects recovered from shipwrecks have thick layers of concretion on them. This can be done either on site or at the conservation laboratory. The removal of the concretion can be done mechanically or chemically: with pewter it is recommended that the concretion is removed mechanically with flat hammers, chisels and soft brushes as this is a chemical sensitive metal. It is, however, recommended that the object be X-rayed first before removing any concretions, just to have detailed information about the object.

Once the objects are cleaned and all the concretions have been removed, it can then be consolidated by an electrolysis caustic soda solution 5% by weight NaOH in water. Consolidative electrolysis is normally applied at a voltage of 4 – 6 volts - this technique reduces corrosion products and consolidates the surface of the corroded pewter (North 1987:245). Following the electrolysis, the object can then be rinsed thoroughly to remove all the NaOH residues: this can be done using tap water with a concentration of approximately 15 drops of concentrated H2SO4 per litre of water, until the PH level remains constant.

2.5 Storage

Pewter objects can be protected from organic acids during storage by applying a protective microcrystalline wax layer. It is important to keep the artefacts away from all sources of organic acids during storage and display. One should avoid storing pewter in drawers or oak cabinets. It is advisable to store these objects in a controlled environment to avoid or block agents of deterioration such as vapours that can initiate corrosion. It is safe to store pewter in sealed containers and polyethylene bags (Hamilton 1999:87).

2.6 Effects of marine environment on pewter corrosion

Before intervening with an object, one should asses the object by doing thorough documentation. One should also have a good understanding of the corrosion products and the composition of the object, as stated by North and MacLeod (1987:71) Corrosion reactions are basically oxidation and reduction reactions, which involves donating and accepting electrons, meaning corrosion products occur in metals when reactants are added to electrons. This happens when metals are placed in water with the presence of oxygen. Corrosion then occurs and this forms pitting, thinning of the metal, blistering, and sometimes green discoloration due to copper in the alloy.

Pewter artefacts that contain a high amount of lead found under aerobic conditions are less corroded compared to those with less lead proportions. A good example of this is the materials recovered from the Shetland Islands, which contained over 50% lead and which had been in the sea for 300 years. They only showed superficial corrosion (North and MacLeod 1987:90). Little has been said on the effects of anaerobic conditions regarding the corrosion of pewter objects, due to the unavailability of reports in conservation and maritime archaeology.

2.7 Composition analysis of pewter

X-ray fluorescence spectroscopy is one of the well-established analytical methods used for the compositional analysis of metal alloys. Samples are excited using X-rays and while the atoms relax back to their ground state, they produce secondary X-rays with energies specific to the spectral line of a specific element. The more atoms of a specific element present in the sample, the higher the intensity of the signal at a specific energy. Thus, the elements of the composition, as well as their relative concentrations can be determined. Pewter, being a tin based alloy, can greatly vary in composition from around 70% tin (Sn) and 30% lead (Pb) of ancient pewter to modern Pewter with around 91% Sn, 7.5% antimony (Sb) and 1.5% copper (Cu) and actually no lead at all. Through the ages and due to different sources of raw material pewter compositions could differ quite a bit and XRF is the ideal tool to investigate the objects and identify even small compositional differences (Bezur et Al. 2020).

No literature on pewter conservation and composition analysis was identified in the Namibian context apart from the substantial reports on the preventive conservation of underwater cultural heritage, as indicated in the introduction of this chapter. The study made use of different literature from around the world.

Weinstein (2011) investigated the British pewter alloys by having a sample of typical objects analysed by ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometry). She also looked at their form and usage, but primarily focused on their conservation aspects. This study focused more on the types of pewter vessels surviving from the period of 1200 – 1700 and how they were domestically used. She used the ICP -OES to analyse a range of smaller drinking vessels and candlesticks which are known to have been produced in the trifle alloy. The results showed an alloy of some vessels containing 4-6% lead and 0.5-1.38% copper. The lead and copper used for these objects is likely to be of European origin (Weinstein 2011:109). This researcher also used this scientific analysis to date these vessels by detecting that the hardeners used in this trifle alloy are bismuth and antimony. Bismuth is recorded to be in use from the sixteenth century only.

In addition to the trifle alloy analysis, Weinstein (2011:109) analysed eighteen other objects from the Neish Collection of British pewter. A few of the analysed objects are marked with the crowned hammer mark and dated from 1500 – 1550. The results were compared with those of Brownsword and Pitt's (1984) medieval and sixteenth century flatware analyses. Both analyses concluded that the objects with the crowned hammer mark are of a second fine grade alloy and are believed to be lead free.

Brownsword & Pitt (1984) did an XRF analysis of English flatware to determine the nature of the alloys used by the English pewterers in the thirteen to sixteenth centuries. Their interest was to see whether the alloys used would have qualified for the Pewterers Company's regulations for fine metal which is known to be a tin/copper alloy. They were also interested in the amount of lead used, as well as the amount of hardeners (bismuth and antimony) which was used from the sixteenth century only (Weinstein 2011:108).

The results from the Mary Rose pewter study (Brownsword and Pitt 1990:109) shows that high tin and low lead alloy was used. These results proved that the Company controls were indeed effective and that pewterers were meeting the standards required for flat wares.

2.8 Theoretical framework

This study is situated within the framework of safeguarding and preserving underwater cultural heritage and is guided by the UNESCO 2001 Convention for the Protection of Underwater Cultural Heritage.

Underwater cultural heritage can be defined as human existing activities with historical, cultural or archaeological significance regarding objects that have been submerged or been partially submerged in water for more than hundred years (Maarleveld et al 2013). These sites open up new windows about our past and give us a great understanding of both local and international history.

The UNESCO 2001 manual convention further states that the significance of underwater heritage such as, shipwrecks, submerged cities and harbours is mostly taken for granted. Deterioration, looting and illicit trafficking are some of the major threats and destructions to underwater cultural heritage that deprives humanity of their heritage. However, the aggressive seas and waves have protected and preserved many wrecks and ruins for centuries, but the advancement in diving techniques made these sites more accessible to everyone including treasure hunters, putting them at high risk (Khakzad 2008).

This study generated results which led to recommendations and the NMN can use these results to develop a strategy or road map for potential improvements. With the main objective of the study being to assess and investigate the condition and possible conservation treatment of the pewter objects at the Oranjemund Shipwreck Collection, the UNESCO 2001 convention appears to be the best guiding framework.

2.9 Chapter Summary

Although not much has been written specifically on the conservation and composition analysis of the pewter objects recovered from the Oranjemund Shipwreck, many writers have written a lot on pewter in general. Deducing from this relevant literature, most of the authors focused on chemical analysis. Some classified and compared different pewter objects while some wrote on manufacturing and uses. Most of their findings and conclusions are however limited mostly to chemical analysis. This left room for further investigating the most suitable conservation and restoration practices for pewter plates recovered from marine environments. The next chapter discusses the methodology for this study.

Chapter 3

Research Methodology

3.0 Introduction

Methodology is the general approach taken through the research process. It implies more than just the method the researcher intends to use for their study; it also considers the methods intended to collect data (Muray & Hughes 2008).

This chapter discusses the methodology that was used for this study and it is arranged and organized in the following subsections: The first section discusses the methods that were used for studying the research problem. The data collection instruments are described in this chapter as well. The study's population is then defined and the methods used to choose the sample from the population are mentioned with reasons why they were the most suitable.

3.1 Mixed Methods and Research Design

This study made use of the mixed method (qualitative and quantitative) case study approach within the interpretive paradigm, utilizing interviews and X-ray Fluorescence Spectroscopy (XRF) analysis technique as data collection methods. The Oranjemund shipwreck is one of the oldest and most intact wrecks ever to be discovered in Sub – Sahara Africa and makes a great case study for this project as it investigated the objects within its real-life context and will make great contributions to the already existing knowledge.

3.1.1 Research Population

Abdi et al. (2010) describes a population as a theoretically specified aggregation of study elements. Population refers to the group targeted by the researcher. As stated by Crawshaw and Chambers (2001), population is regarded as the entirety of groups about which the researcher would like the results of the study to be generalized. It is described by Josef and Veldhuis (2006) as an entire group of people, objects or events which have at least some characteristics in common. It is the group the researcher works with in order to answer research questions. According to Burns and Grove (1997), population is all elements (individuals, objects and events) that meet the sample criteria for inclusion in a study. Therefore, population is defined as including all people or items with the characteristics one wishes to understand. The population hence refers to respondents or participants and I selected. In the case of the Oranjemund shipwreck collection, staff that totalled 4 participants and 50 pewter objects out of 100 in the Oranjemund collection was used.

3.1.2 Sampling Design and sampling size

Sampling is the process of selecting a portion of a population to represent the entire population. The researcher used the non-purposive sampling technique to choose participants who were knowledgeable about the Oranjemund collection.

The research population was the 4 respondents who were directly involved with the collection. The structured interview guide used can be seen in Appendix A. For the artefacts there are a hundred pewter objects in the Oranjemund collection. Fifty artefacts were randomly selected and analysed.

3.2 Interviews

Semi-structured interviews were used as one of the data collection instruments. An interview guide was prepared (Appendix A) and four participants were interviewed at the Oranjemund Shipwreck Collection in Namibia. The interviews were conducted in the participants' respective offices and each interview lasted not more than 20 minutes. Open ended questions were used. Data was obtained by interviewing a curator and three technical assistants who work with the shipwreck collection, as they are the people caring for the objects since their recovery. The interview questions focused on the preservation and conservation aspect of the pewter collection. One advantage of using open-ended questions is that it allowed respondents to answer in their own words and also allowed for follow up questions. Unfortunately, the interviews were not recorded because no cell phones (intended recording device) were allowed into Namdeb's mining area, as that is where the Oranjemund Shipwreck Collection is housed.

3.3 Archival, historical research and museum collections

The Oranjemund museum archive has a database of all the objects that were recorded during the excavation. This database was extensively consulted during this research in order to establish the various objects for research. Chirikure (2010) recorded 5338 archaeological artefacts from the Oranjemund shipwreck. This record, coupled with the site recording forms containing contextual descriptions of the excavations, was consulted during this research. As a result, pewter alloy objects were identified using this database. Such evidence was important because it gave a history of how the collection was managed. Contemporary conservation and preservation documents were also consulted as part of this research.

3.4 XRF Analysis

The pewter objects were analysed using X-ray Fluorescence Spectroscopy (XRF) in situ at the Oranjemund shipwreck collection. M. Loubser, a senior lecturer in the Tangible Heritage Conservation programme at the University of Pretoria, travelled to Namibia (Oranjemund) with a handheld XRF spectrometer due to the lack of similar equipment in Oranjemund.

The analytical method of choice for the quantitative analyses of the pewter was X-ray Fluorescence Spectroscopy. This method performs elemental analyses for all elements on the periodic table between Magnesium and Uranium. The basic fundamental of the method is that the atoms in a sample is excited by an X-ray tube and in the relaxation of the atom, X-ray photons with a specific energy for each of the specific orbital transitions of the atom is generated (Bezur et. Al. 2020).

This results in a spectrum with signals at very specific energies, directly translated to the elements present in the sample. The amount of a specific atom present in the sample (concentration of the element), also influences the intensity of the peaks in the spectrum and in this manner, calibrations can be done by comparing the peak intensities in counts per second (cps) to the concentration in percent (%) or parts per million (ppm).

In this case the analyses were executed using a Bruker Tracer 5i handheld spectrometer and the factory Alloys calibration was used. Said calibration was deemed adequate, as the effect of the lack of sample preparation on the pewter was going to outweigh any possible increase in accuracy a custom calibration could have provided.

The two-phase calibration used a 40kV excitation with an TiAl filter to cover elements between Titanium (Ti) and Bismuth (Bi) on the periodic table, and a second excitation at 15kV with no filter to optimally excite elements between Magnesium (Mg) and Sulphur (S) without saturating the detector with signal from the heavier elements.

The samples were prepared by the curator and technical assistant in the collection by setting up three different stations. Station A was the recording of the weight, length and width of the objects. Station B was for surface cleaning and selecting the best surface to analyse with the handheld spectrometer. Surface cleaning was done mechanically using diamond paste and ethanol because many of these objects were covered in concretion. The team tried to remove as much as possible while being sensitive to the integrity of the objects. Station C is where the analysis with the XRF was done. The samples were then packed back into their storage trays.

The Bruker Tracer Alloy factory calibration is very accurate for metals, as it uses Fundamental Parameters (Thomsen 2007) as matrix correction model. Background and line overlap corrections are also handled by the software. These corrections assume a perfect sample though – flat, homogenous, and clean. XRF is a surface method as the X-ray photons can only escape a few microns from the surface of the sample, depending on its density, so surface effects can influence the accuracy of quantitative analyses severely.

X-ray fluorescence (XRF) is a widely used method of chemical analysis in archaeological research. Shackley (2001) states that the method is essentially non-destructive, thereby making it particularly attractive for the analysis of archaeological objects. Handheld X-ray fluorescence was successfully used in obsidian provenance as well, because of its potential to make the greatest impact through non-destructive analysis (Ferguson 2012).

Archaeometallurgy is a growing field in archaeology and complex analytical tools such as advanced optical light microscopes (OLM), X-ray fluoroscopy (XRF), laser –ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) and scanning electron microscopes (SEM), among others, make it possible to analyse ore and metal products with great precision (Thornton & Roberts 2014).

3.5 Chapter Summary

This chapter covered the research methodology used by the researcher. It emphasised the research approach and dwelt on the research paradigm and research design used while clarifying the advantages and limitations. It also spelt out the targeted population. The sample was also explained including the sampling procedures used. Instruments, namely interviews, archival and XRF analysis were discussed. The following chapter (chapter 4) focused on data presentation, analysis and interpretation.

Chapter 4

Data Presentation and analysis

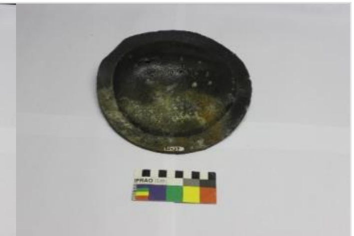
4.1 Introduction

This chapter presents quantitative and qualitative data collected through the methods of interviews, observation and X-ray Fluorescence Spectroscopy (XRF) analysis. Data is presented in the form of a descriptive narrative, with the use of direct quotes and tables. The chapter is organized into themes informed by the research objectives, which are: Condition assessment of all analysed objects, composition and alloy characteristics of the pewter objects and their conservation aspects.

4.1.1 Condition Report

The current location of all these objects is the Oranjemund Shipwreck Collection in Oranjemund Namibia. As these are marine artefacts, most objects have concretion and encrustation and many are deformed. In the condition reporting the different types of objects are presented together. To make reading easier it was done in tabular form. Every object was photographed from the back and the front. The date of the shipwreck was confirmed to be 1533, so all objects are assumed to be from the sixteenth century and older.

Table 3: Catalogue of plates in collection

B6037	A small plate in a deformed shape. The plate is rusty inside and it has a small hole through it.	Width220mm ; weight 506g.	good condition		
B7320	A medium sized plate in a deformed shape. The plate is heavily bent and it is mostly covered in concretion.	Width 220mm; weight 643g	bad condition		
B6034	A medium sized plate slightly deformed. The plate is badly rusty inside and it is slightly covered in concretion.	Width 226mm ; weight 616g	fair condition		
B7311	A small plate in a deformed shape. The plate is rusty inside and it has a fold-like bend.	Width 228 mm; Weight 572g	bad condition.		
B7309	A small plate in a good condition. It is partially rusty and its covered in slight concretion	Width 221mm; Weight ???	good condition.		

B7347	A small plate estimated to be in a fair condition. It is partially covered in concretion and has a hole through it	Width210 mm; Weight …..g.	fair condition		
B6137	A plate, believed to be in a fair state and covered slightly in concretion.	Width 265mm; Weight …….g.	fair condition		
B7311	A small plate believed to be in a fair condition. It is stained both in the inside and the outside.	width of 265mm and it weighs …….g.	fair condition.		
B7348	A small plate in a deformed shape. It is covered in small layers of concretion.	Width 220mm; Weight …..g.	fair condition.		
B6144	A small plate in a deformed shape. It has a crack-hole in the centre and partially covered in concretion inside.	Width 228mm; Weight ….g.	fair condition.		

B6142	A plate, believed to be in a fair condition. It is covered in heavy concretion inside and outside.	Width 242mm; Weight …….g.	fair condition.		
B7343	A small, rusty plate in a slightly-deformed shape, believed to be in a fair condition. It is covered in concretion and has a hole on the side.	Width 223mm; Weight …..g.	fair condition.		
B7310	A plate in a deformed shape. It is partially rusty inside and it is covered in concretion.	Width 198mm; Weight ……g.	fair condition.		
B7319	A plate in a deformed and slightly bent shape. It is rusty and is covered in sea incrustation and concretion.	Width 235mm; Weight …….g.	fair condition.		
B7340	A plate in a deformed shape. It is rusty and folded in half, with slight concretion.	Width 221mm; Weight ……g	bad condition		

B7315	A small plate in a deformed shape, believed to be in a fair condition. It is bent on both sides, rusty and is covered in heavy concretion.	Width 225mm; Weight …….g.	fair condition		
B7332	A rust plate in a deformed shape, believed to be in a bad condition. It is covered in a heavy concretion on one side and it has two bib holes through it.	Width 261mm; Weight….	bad condtion		
B7329	A plate in a damaged and deformed shape, believed to be in a fair condition. It is partly covered in concretion and has two comparatively big holes on the side.	Width 336mm; Weight ……g.	fair condition		
B7339	A plate in a deformed shape, believed to be in fair condition. It is covered in a small layer of concretion and it is damaged badly on one side.	Width 302mm; Weight …..g.	bad condition		
B7330	A plate in a deformed shape, believed to be in a very bad condition. It is covered in concretion and severely damaged with a big opening in the middle.	Width 348mm; Weight ……….g.	bad condition.		

B7777	A plate in a deformed and damaged shape, believed to be in a fair condition. It is rusty, partly covered in concretion and missing some parts on the side. It also has a few holes in the middle	Width 270mm; Weight …….g.	bad condition.		
B7297	A small plate in a deformed shape. It is rusty, covered in concretion, heavily bent and nearly a quarter of it missing.	Width 270mm; Weight ….g.	bad condition.		
B6035	A small plate in a deformed shape. It is rusty and covered in concretion. It is also bent into a shape of a hat, and it is missing a part.	Width 161mm; Weight …….g.	bad condition.		
B7297b	A small piece of plate in a deformed and severely damaged shape. It is rusty and covered in concretion. It is also severely damaged that it is only a small piece of the object, suspected to be a plate left.	Width 202mm; Weight ……..g.	bad condition.		
B7350	A small plate in a severely deformed shape. It is folded from both sides into a shape of a rock. It is rusty and covered in concretion.	Width 195mm; Weight …g.	bad condition.		

B6146	A small plate in a severely damaged and deformed shape, believed to be in a bad condition. The plate is even starting to corrode.	Width 155mm; Weight ….g.	bad condition.		
B7335	A plate in a deformed shape, believed to be in a fair condition. It is heavily covered in concretion.	Width 240mm; Weight ……g.	bad condition.		
B7327	A plate in a deformed shape. The plate is rusty and it is folded on the side with a heavy layer of concretion.	Width 210mm; weight ….g.	bad condition.		
B7384	A plate in a deformed shape, estimated to be in a fair condition. The plate is rusty with a thin layer of concretion	Width 216mm; Weight …….g.	fair condition		
B7317	A plate in a deformed shape, believed to be in a bad condition. The plate is rusty and it has a wide opening through the middle.	Width 220mm; Weight …….g.	bad condition		

B7334	A plate in a deformed shape, believed to be in a bad condition. The plate is rusty and it is folded completely in half, with a heavy layer of concretion.	Width 220mm; Weight …….g.	bad condition.		
B6041	A plate in a deformed shape. The plate is rusty and it is folded completely with a heavy layer of concretion and it is starting to corrode.	Width 329mm; Weight …….g	bad condition.		

4.1.2 XRF Composition Plates Results

Table 4: XRF composition plates results

Composition %	Mg	Al	Si	P	S	Mn	Fe	Cu	Se	Ag	Sn	Au	Hg	Pb	Bi
B6034	0.80	< LOD	1.57	< LOD	< LOD	0.50	9.49	8.30	< LOD	< LOD	69.07	0.45	0.09	8.69	0.12
B6035	0.67	< LOD	1.45	< LOD	< LOD	0.22	18.32	4.88	< LOD	< LOD	63.37	0.37	< LOD	9.62	0.08
B6037 clean sample	1.04	< LOD	1.40	< LOD	< LOD	0.38	0.86	0.61	< LOD	< LOD	89.13	0.11	< LOD	6.19	0.10
B6041	< LOD	< LOD	< LOD	< LOD	< LOD	0.10	1.22	2.58	0.03	< LOD	83.11	< LOD	< LOD	12.11	< LOD
B6137	0.88	< LOD	0.97	0.06	4.34	0.19	19.81	16.17	< LOD	< LOD	47.30	0.42	0.02	9.22	0.13
B6142 edge	0.41	< LOD	0.76	< LOD	2.22	0.28	3.48	12.14	< LOD	< LOD	56.81	0.20	0.01	23.66	< LOD
B6144 edge	0.72	< LOD	0.96	< LOD	2.83	0.58	9.13	7.35	0.01	< LOD	61.38	0.52	0.02	16.26	< LOD
B6146	1.21	< LOD	1.28	< LOD	< LOD	0.21	14.63	7.49	< LOD	0.10	66.49	0.29	0.02	8.17	< LOD
B7297 Au	0.72	< LOD	< LOD	< LOD	4.13	0.07	8.13	13.44	< LOD	< LOD	59.53	0.27	< LOD	13.50	< LOD
B7297 B	0.73	< LOD	< LOD	< LOD	< LOD	0.11	23.23	5.47	< LOD	< LOD	67.13	0.12	0.05	2.93	0.13
B7309 bottom 1	0.37	< LOD	1.37	< LOD	1.17	0.14	10.71	5.99	< LOD	< LOD	74.60	0.23	< LOD	5.21	0.10
B7310	< LOD	< LOD	0.61	< LOD	1.94	0.19	0.79	1.82	0.02	< LOD	85.66	< LOD	< LOD	8.45	< LOD
B7311	< LOD	< LOD	0.52	< LOD	< LOD	0.24	2.83	3.20	0.02	< LOD	83.63	< LOD	< LOD	8.80	< LOD
B7311 edge	0.98	< LOD	1.82	< LOD	< LOD	0.13	12.81	6.09	< LOD	< LOD	70.85	0.16	< LOD	6.43	0.05
B7315	0.38	< LOD	1.31	< LOD	1.40	0.01	3.18	6.69	< LOD	< LOD	77.02	0.51	0.02	9.10	0.10
B7317 clean Au	< LOD	< LOD	1.01	< LOD	< LOD	0.20	1.27	2.26	0.02	< LOD	87.35	< LOD	< LOD	7.37	< LOD
B7317 white spot	< LOD	< LOD	0.97	< LOD	< LOD	0.15	1.73	1.12	0.02	< LOD	87.78	< LOD	< LOD	7.59	< LOD
B7319 calcretion an	< LOD	< LOD	< LOD	< LOD	3.42	0.09	52.34	2.82	< LOD	< LOD	39.70	< LOD	0.01	1.36	0.16
B7320	< LOD	< LOD	0.82	< LOD	< LOD	0.04	4.45	0.77	0.04	< LOD	78.05	< LOD	< LOD	14.44	< LOD
B7322	< LOD	< LOD	< LOD	< LOD	< LOD	0.43	1.38	1.77	0.03	< LOD	83.17	< LOD	< LOD	12.26	< LOD
B7327 Au	< LOD	< LOD	0.63	< LOD	3.22	0.04	34.90	0.42	< LOD	< LOD	56.09	0.21	0.06	3.90	0.22
B7330 Au	0.60	< LOD	0.89	< LOD	2.70	0.07	12.20	0.84	< LOD	< LOD	73.22	0.15	0.03	8.74	0.22
B7332 rusty	0.54	< LOD	< LOD	< LOD	2.59	0.04	40.68	0.32	< LOD	< LOD	52.14	0.11	< LOD	3.23	0.23
B7334 Au	1.09	< LOD	5.75	< LOD	< LOD	0.17	11.52	0.55	< LOD	< LOD	74.05	0.50	< LOD	4.78	< LOD
B7335 nice clean sa	< LOD	< LOD	< LOD	< LOD	< LOD	0.02	0.77	3.42	0.03	< LOD	80.10	< LOD	< LOD	14.42	< LOD
B7339 rusty	0.70	< LOD	1.65	< LOD	1.34	0.06	14.90	0.29	< LOD	< LOD	80.42	< LOD	< LOD	0.35	< LOD
B7340	< LOD	< LOD	0.77	< LOD	< LOD	0.11	2.04	0.58	0.04	< LOD	81.42	< LOD	< LOD	14.23	< LOD
B7342	< LOD	< LOD	< LOD	< LOD	< LOD	0.28	3.08	3.56	0.02	< LOD	82.29	0.05	< LOD	9.47	< LOD
B7343	< LOD	< LOD	0.24	< LOD	4.65	0.02	41.47	6.33	< LOD	< LOD	39.11	0.49	0.07	6.60	0.53
B7347	1.77	< LOD	1.31	< LOD	< LOD	0.22	8.25	4.72	< LOD	< LOD	77.28	0.31	< LOD	6.06	0.07
B7348	< LOD	< LOD	0.94	< LOD	< LOD	0.06	0.30	0.51	0.02	< LOD	89.51	< LOD	< LOD	7.93	0.04
B7350 high S	0.35	< LOD	1.39	0.01	4.28	1.53	51.35	0.08	< LOD	< LOD	39.75	< LOD	< LOD	1.23	< LOD
B7777	0.45	< LOD	1.34	< LOD	1.23	0.19	21.39	0.91	< LOD	< LOD	71.96	< LOD	< LOD	2.16	0.18
Average	0.76	< LOD	1.27	0.03	2.76	0.22	13.41	4.05	0.03	0.10	70.56	0.29	0.04	8.32	0.15
Minimum	0.35	< LOD	0.24	0.01	1.17	0.01	0.30	0.08	0.01	0.10	39.11	0.05	0.01	0.35	0.04
Maximum	1.77	< LOD	5.75	0.06	4.65	1.53	52.34	16.17	0.04	0.10	89.51	0.52	0.09	23.66	0.53

Limit of Detection (LOD) in the above figure indicates below limit of detection, which can usually be described as three times the standard deviation of the background signal.

Most of the objects with clean surfaces were plates, so we focused on these for our composition analyses as follows

There is a range of compositions found in the analysed plates as shown in figure 1. Magnesium (Mg) is found in sea water and it's not an element found in the plates. No Aluminium (Al) was observed because aluminium was only used as a metal from 1827 and the plates in question are from the 16th century (Making Metals Powder, 2021). The Silicon dioxide (SiO_2) is found in quartz sand that formed part of the concretion that's evident on several plates. No Potassium (K) was found, except in two plates B6137 and B7350 which is < 600ppm and this could be from animal bones as lots of animal bones were recovered with the artefacts. (Oranjemund shipwreck accession)

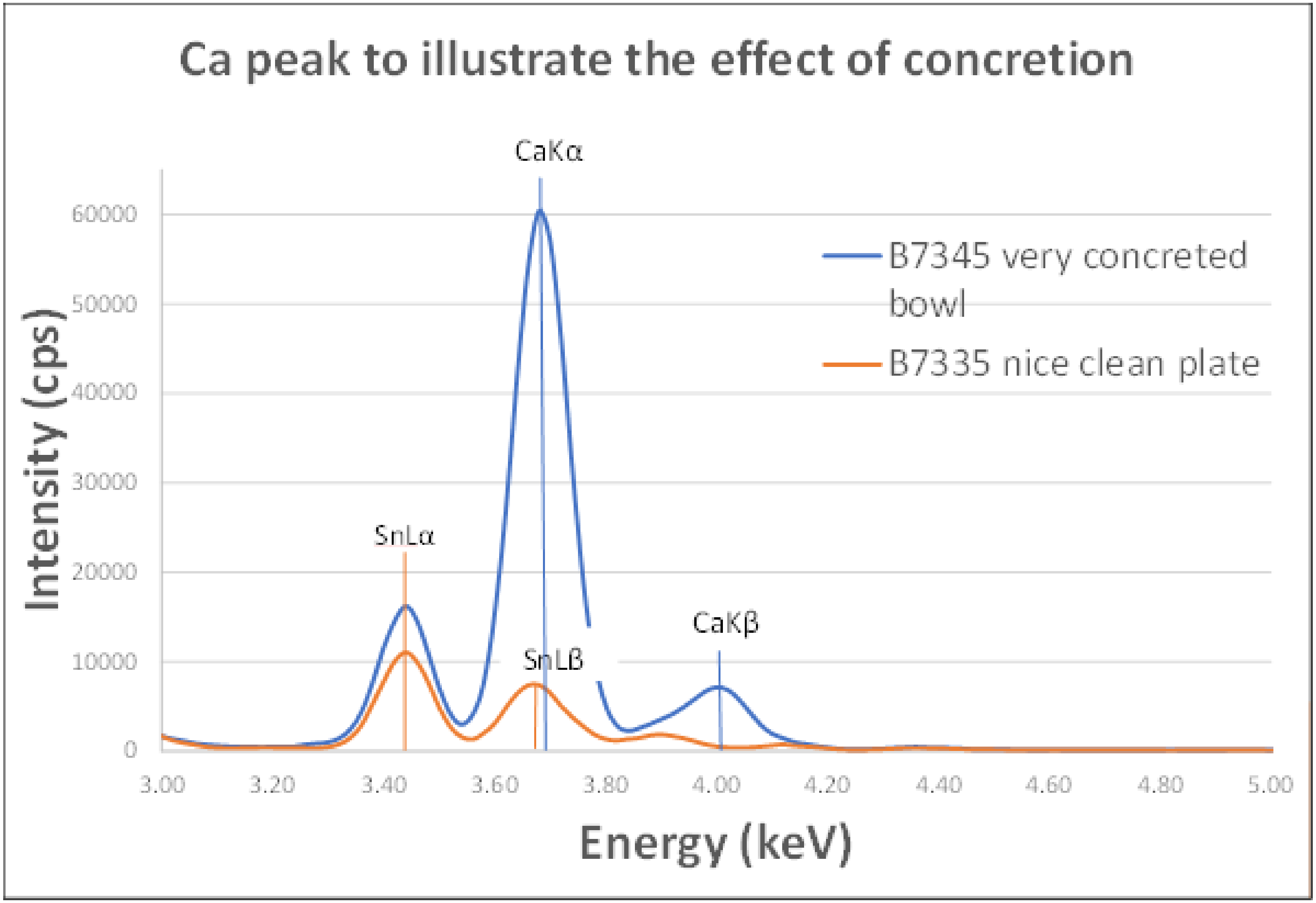


Figure 1: Illustrating the effect of concretion.

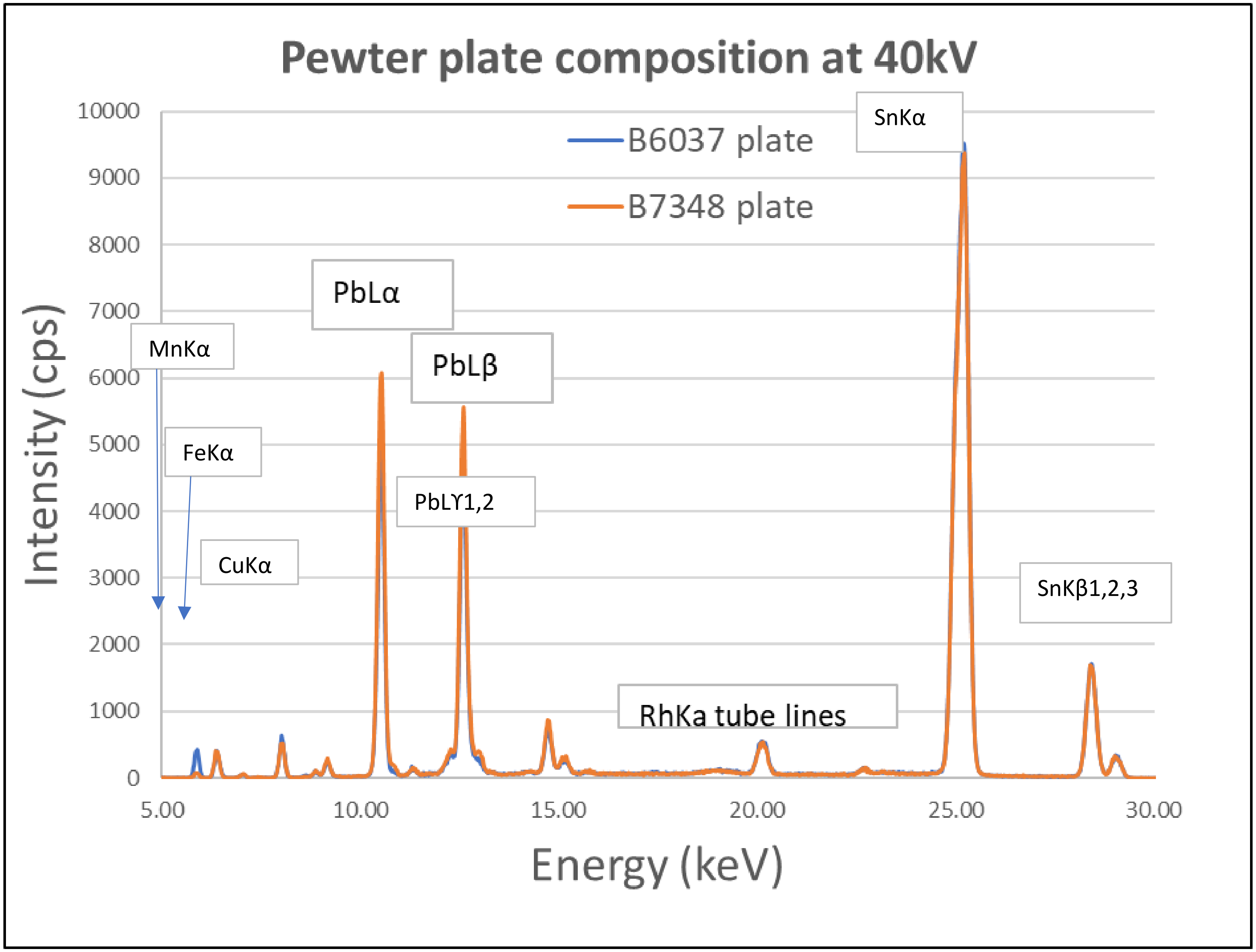


Figure 2: Pewter composition on cleat plates at 40kV.

The corresponding quantitative analysis gives average pewter composition for the plates as follows.

Composition %	Cu	Sn	Pb	Bi
B6037 clean sample	0.61	89.13	6.19	0.10
B7348	0.51	89.51	7.93	0.04
average	**0.56**	**89.32**	**7.06**	**0.07**

Composition %	Cu	Sn	Pb	Bi
B6041	2.58	83.11	12.11	< LOD
B7320	0.77	78.05	14.44	< LOD
B7322	1.77	83.17	12.26	< LOD
B7335 nice clean sample	3.42	80.10	14.42	< LOD
B7340	0.58	81.42	14.23	< LOD
average	**1.82**	**81.17**	**13.49**	**< LOD**

4.1.3. Condition report (Jugs, lids and handles)

Table 3: Catalogue of jugs and lids

B7365	A jug in a deformed shape. It is very rusty and it is badly covered in concretion.	Width of 125mm; Length 228mm & Weight 1465g	good condition		
B7386	A jug in a deformed shape. It is rusty and covered in concretion.	Width 115mm; Length 420mm & Weight 1316g	bad condition		
B7344	A Jar handle, detached from the main object. It is covered in rust.	Width 210mm; Weight 375g	fair condition		
: B6093	A jug with its lid and handle. It is covered in heavy concretion.	Width of 85mm; Height 145mm & Weight 914g.	fair condition		
B7338	A jar lid with a detached pivot. It ha is covered in heavy concretion.	Width 127mm; Weight	fair condition.		

B6533	A jar lid with its pivot attached to it, but detached from the main object. It is partially covered in rust and concretion.	Width 90mm; Weight….	good condition		
B6545	A fairly small Jar lid. It is partially rusty and it has visible maker's seal or trademark	Width 77mm; Weight …..g	good condition.		
B6546	A fairly small jar lid. It is partially covered in concretion.	Width 93mm; Weight …..g.	good condition.		
B6040	A jug in a deformed shape, with a handle still intact. It is believed to be in a fair state. The jug is rusty and it is folded on the side with a heavy layer of concretion.	Width 190mm; Height 170mm; Weight …….g.	bad condition.		
B7326	A Jug lid in a deformed shape, with a handle attached to the top, believed to be in a fair condition. The jug is rusty, with a heavy layer of concretion and has started corroding.	Width: 175mm; Height: 190mm; Weight…	fair condition.		

B7365	A Jug in a deformed shape. The jug is rusty and covered with a heavy layer of concretion. It does not have a handle and it has a hole through the base.	Width: 125mm; Height: 110mm; Weight…	bad condition.		
B7386	A Jug handle in a believed to be in a fair condition. The handle is rusty, on its own and detached from the main object. It is corroding.	Width 85mm; Weight …….g.	bad condition.		
B7336	A Jug handle in a believed to be in a fair condition. The handle is rusty, on its own and detached from the main object. It is corroding.	Width 85mm; Weight …….g.	bad condition		
B6039	A Jug in a deformed shape. The jug is rusty and covered with a heavy layer of concretion. It does not have a handle and it has a hole through the base.	Width 125mm; height 110mm & Weight …….g	bad condition		

4.1.4 XRF Composition jugs, lids and handles Results

Table 4: XRF composition jugs, lids and handles results

Name	Mg	Al	Si	S	Mn	Fe	Cu	Se	Ag	Sn	Au	Hg	Pb	Bi
B6039 Au	1.08	< LOD	1.55	< LOD	0.25	2.13	12.58	< LOD	< LOD	66.01	0.55	0.01	15.21	< LOD
B6040	1.58	1.65	23.32	5.00	7.69	30.50	0.75	< LOD	< LOD	21.94	< LOD	< LOD	0.80	< LOD
B6093	1.25	< LOD	< LOD	< LOD	0.45	11.89	7.14	0.01	< LOD	60.74	0.88	< LOD	17.37	< LOD
B6446	0.52	< LOD	1.85	2.52	0.13	16.57	1.76	< LOD	< LOD	64.80	0.44	< LOD	11.38	< LOD
B6533	0.48	< LOD	2.90	1.52	0.11	15.31	1.53	< LOD	< LOD	72.11	< LOD	< LOD	5.91	0.10
B6545 beautiful visibl	< LOD	< LOD	2.71	< LOD	0.16	0.68	0.27	0.04	< LOD	80.08	< LOD	0.01	14.78	< LOD
B7326	< LOD	< LOD	0.67	< LOD	0.77	2.74	0.81	0.05	< LOD	76.10	< LOD	< LOD	17.84	< LOD
B7336	< LOD	< LOD	0.91	3.07	0.21	2.05	0.21	< LOD	< LOD	92.48	< LOD	< LOD	0.87	< LOD
B7338 rusty	< LOD	< LOD	1.13	< LOD	0.35	2.52	0.47	0.03	< LOD	85.21	< LOD	< LOD	9.58	< LOD
B7344	< LOD	< LOD	0.74	< LOD	0.33	1.40	0.31	0.03	< LOD	84.98	< LOD	< LOD	11.33	< LOD
B7365 whole jug	< LOD	< LOD	0.33	6.47	0.02	15.71	11.35	0.02	0.08	44.95	0.46	0.01	20.32	< LOD
B7386	< LOD	< LOD	0.83	< LOD	< LOD	2.00	0.74	0.06	< LOD	72.48	< LOD	< LOD	22.58	< LOD
Average	0.98	1.65	3.36	3.71	0.95	8.62	3.16	0.03	0.08	68.49	0.58	0.01	12.33	0.10
Minimum	0.48	1.65	0.33	1.52	0.02	0.68	0.21	0.01	0.08	21.94	0.44	0.01	0.80	0.10
Maximum	1.58	1.65	23.32	6.47	7.69	30.50	12.58	0.06	0.08	92.48	0.88	0.01	22.58	0.10

We managed to analyse pewter jugs, lids and handles as well and their composition was slightly different from that of the plates as shown in figure 4. B7336 (a jug handle which is believed to be in a fair condition) has a pretty unique composition as it seems to have 92% Sn and almost no Pb, Bi or Cu.

Other objects with a very different composition worth mentioning are B6039 and B7365, which has Cu, Sn, Au, Pb and no Bi as shown below. This has a very different composition. Hg was found in a few samples which could have been contamination by the mercury recovered with the pewter objects and not part of the inherent composition.

Name	Cu	Sn	Au	Pb	Bi
B6039 Au	12.58	66.01	0.55	15.21	< LOD
B7365 whole jug	11.35	44.95	0.46	20.32	< LOD

Three pewter bowls were part of the analysed samples as well and yielded the following results:

Table 5: Catalogue for pewter bowls

Accession number	**Object Description**	**Measurements**	**Condition**	**Images**
B7345	A rusty bowl with 2 handles. It is partially covered in concretion on the outside.	width; 224mm Height of 38mm & Weight 430g.	bad condition	 
B7318	A rusty bowl, with its 2 handles. It is covered in concretion.	Width 227mm; Height of 37mm & Weight 883g.	bad condition	 
B7331	A bowl in a severely deformed shape. It is rusty and covered in a heavy concretion. It also has a hole on the side.	Width 295mm; Weight 511g.	bad condition.	 

Table 6: XRF results for pewter bowls

Name	Mg	Al	Si	P	S	Mn	Fe	Cu	Se	Ag	Sn	Au	Hg	Pb	Bi
B7331 concreted and rusty	0.72	< LOD	1.51	< LOD	1.91	1.29	25.66	0.22	< LOD	< LOD	64.93	0.08	< LOD	3.26	0.14
B7345 very concreted	< LOD	< LOD	< LOD	< LOD	< LOD	0.17	1.31	0.32	0.02	< LOD	84.19	0.13	< LOD	12.07	< LOD
B7345 rusted underside	0.42	< LOD	1.38	< LOD	1.88	0.09	26.38	3.37	< LOD	< LOD	62.84	0.18	0.02	3.22	0.11
B7318 very concreted	4.33	3.03	14.23	< LOD	4.92	9.30	21.99	4.50	< LOD	< LOD	30.60	< LOD	< LOD	< LOD	< LOD
Average	1.82	3.03	5.71	< LOD	2.90	2.71	18.83	2.10	0.02	< LOD	60.64	0.13	0.02	6.18	0.13
Minimum	0.42	3.03	1.38	< LOD	1.88	0.09	1.31	0.22	0.02	< LOD	30.60	0.08	0.02	3.22	0.11
Maximum	4.33	3.03	14.23	< LOD	4.92	9.30	26.38	4.50	0.02	< LOD	84.19	0.18	0.02	12.07	0.14

These bowls are heavily covered in concretion and nicely cleaned surfaces couldn't be located. An analysis was done through the concretion and that's why many elements were below limit of detection.

4.2 Conservation aspects of pewter objects at the Oranjemund collection

To get more insight of the current conservation practices and aspects of the pewter objects at the Oranjemund shipwreck collection, a structured interview guide was prepared for the staff members at the collection (Appendix A).

In total, four interviews were carried out with different participants at the Oranjemund Shipwreck Collection in Namibia. First to be interviewed was the curator of the collection followed by the technical assistants. They are coded as respondents A, B, C and D for the purpose of confidentiality.

Table 7 below shows the interview respondents and the codes assigned to them.

Table 7: Respondents table

Respondent	Code
Staff Member 1	A
Staff Member 2	B
Staff Member 3	C
Staff Member 4	D

From the combination of the answers of the four respondents, the following conclusions were drawn:

4.2.1 Storage facility

Conservation and preservation are concerned with the well-being of the materials, which is only possible if they are kept in a suitable place. The storage building has negative impacts on the preservation and conservation of underwater materials. The Oranjemund collection storage facility was found to currently not be at the international standards to be a permanent storage facility for this type of heritage, as it does not adhere to ICOM'S definition of what a proper storage space should be (Sandahl 2019).

The pewter artefacts are stored in a dim lit building with no temperature monitoring systems in place. This is what respondent A had to say about the building suitability: "Of course the building was not built to house or store underwater cultural materials, but changes and renovations were made to the building so it can accommodate these types of heritage. The building is divided into different sections like Wet area and Dry area, since there are some objects that need to be submerged and some have to be kept in a dry open space. Humidifiers and air conditioners were installed to regulate and monitor the temperature fluctuation, so I believe that the building is fit, although there are some more renovations which need to be done to bring this building at the world class level or to suit the standards required for these types of heritage." However, from the observations check list, it shows that the installed air conditioning and the humidifiers are not working and the temperature inside the building is not being regulated.

4.2.2 Collection access

The possibility of the public having access to a collection gives it greater publicity and this often leads to an increased perceived value in society and greater access to funding towards conservation. Gathering information on material use at this institution, the interviewer asked respondents B, C and D: “How often do you interact with this pewter objects?” Respondent B responded: “Almost monthly, until I was transferred to the head office in Windhoek, because I used to monitor and clean them once a month.” Respondent C responded: “No, I don’t interact with these objects since am just a handyman.” Respondent D answered: “Not really daily, but I used to help with retrieving and shelving whenever we have researchers.” Another question posed to the respondents was: “On average, how many visitors/researchers do you get per day?” Respondent B responded: “Not more than 2 researchers per month but we get 5 – 8 visitors per day which are mine workers.” Respondent C said; “2 to 6 per day”, while respondent D answered: “Not more than 10 per day.”

4.2.3 Training

To gather information about training in conservation, the interviewer asked: “Has your staff ever received any training on preservation or conservation? If yes, how often do they get it? If no, in what way does it affect the Oranjemund shipwreck collection?” Respondent A responded by saying: “Only on-site training that was offered for few days. I believe this has affected the institution negatively, because they could do a lot better in terms of preservation and conservation than they are currently doing.”

Another interview was done, whereby respondents B, C and D were asked by the interviewer: “Apart from your qualification and experience, have you ever received any other formal training on preservation and conservation of museum objects, specifically underwater materials such as metals? If yes, how often, and how useful was it? If no, do you think it would be necessary?” Respondent B answered: “Yes, I received a short course training in museum objects conservation, majored in paper, ceramics and metals. It was very useful; I have acquired knowledge on first aid conservation and how to handle the fragile objects.” Respondent C responded: “No, I haven’t received any training. Of course, it will help especially with conservation because now no one of us can do any treatment to these objects." Respondent D said: "No, I did not get any training. I think it would have made my job easier."

There are always challenges in any organisation. On issues of possible challenges, the interviewer posed a few questions: "Are there any challenges which the Oranjemund Shipwreck Collection is faced with, regarding preservation and conservation? If yes, what are they, and what has been/need to be done to resolve them? Respondent A answered saying: "Yes there are temporally challenges. We don't have qualified conservators, only had one maritime archaeologist who left us for another institution. The conservation unit is not functional at all. In the absence of conservators, deterioration is taking its toll on most of these objects. The collection is understaffed and it needs experts in conservation and digitization. We are working on sending some our interested staff members for further study; we also busy looking at partnerships with other institutions, especially the universities."

4.3 Chapter summary

This chapter discussed the analysis and interpretation of data that was collected through XRF analysis and interviews. The collected data is integrated under the relevant subheadings. The chapter arranged data collected according to themes, which were motivated by the research objectives. To ensure privacy and confidentiality of the participants, codes were used to represent the participants, no name or any personal identity was revealed in this chapter. Some of the information in this chapter is summarized in forms of tables and charts for clarity. The next chapter discusses the study findings, as well as provides some recommendations and conclusion.

Chapter 5

Summary of findings and recommendations

5.0 Introduction

The previous chapter provided discussions, analysis and interpretation of the findings addressing the following questions driving this study:

- Are there any similarities between the compositions of the objects?
- To investigate the chemical composition and alloy characteristics of the pewter plates.
- Are the compositions of the alloys of these plates typical of sixteenth century pewter?
- To analyse the corrosion products of the pewter plates.
- What is the appropriate storage environment for marine recovered pewter plates?

This chapter presents conclusions drawn from analysis and discussion of the collected data as well as the recommendations for future preservation and conservation.

5.1 Discussion of findings

The first objective was to establish the chemical composition and alloy characteristics of the pewter plates. An XRF analysis was used to analyse the pewter composition. We focused more on the plates as they had the cleanest surface suitable for analysis. There is a range of compositions found in the analysed plates, as discussed in the previous chapter. Analysis was only used where clean spots without concretion or encrustation could be found in estimating average alloy compositions. Without completely removing the concretion, and thus compromising the history of the objects, it was almost impossible to collect enough pewter compositional data to confirm if these objects are from the sixteenth century. Tin (Sn) is the main component of pewter - usually 70 - 90%, depending on the quality of the material. In these plates concentrations varied between 80 -90%. Lead (Pb) concentrations between 7- 14% were found on the clean plates. This agrees with standard pewter compositions of the period in question (10 - 20%) (Beagrie 1989).

Bismuth (Bi) also started to be added to pewter in the late 16th century so compositions between 0.04 and 0.1% were found in some plates. Pewter is a known alloy of Tin and Lead and in many cases the alloy's composition varied, depending on the type of object that was manufactured. Lead in pewter goes from less than 1% up to 40% and alloys with more than 40% were categorized as poisonous and were never used for food related items (Castro 2000).

What is maybe more telling of the sadware is the shape of the plates:[1]

Figure 3: The most important sadware styles and their main periods of use. https://www.pewtersociety.org/about-pewter/pewter-eating

When comparing the picture from the Pewter society, the pewter plates in the collection seem to show good correlation to the 1450 - 1670 sadware, with a plain rim and a gently rounded "bouge" where the rim is joined to the well (table Y). It is difficult to speculate on a raised centre well due to the condition of the plates.

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[1] Sadware is the term used for pewter items used as eating utensils, ie. plates, saucers, dishes and serving trays. https://www.pewtersociety.org/about-pewter/pewter-eating

Some of the analysed objects have markings, which are assumed to be maker's marking. Attempts to identity those markings were unsuccessful because what is left of the markings are not legible, even after image enhancement. As a future project the collection management would be approached to send us the actual item to enable us to do technical photography on the object to try to enhance the markings with raking light, UV or IR photography.

Figure 4: The illegible seal on a jug lid. Photo credits: Nakale 2021.

The next objective was aimed at assessing conservation conditions of the pewter kitchen ware. This study investigated the condition and conservation treatment of the pewter objects at the Oranjemund Shipwreck Collection and revealed how they can be managed under the current conditions. The condition of the objects was assessed using the following variables: good, fair and bad. The objects that made great samples were the ones with less corrosion, that were intact, and that had wider surfaces. Out of the 50 objects examined 8 were in good condition, 20 were fair and 22 were in bad condition. Most of the objects are in bad shape and are in need of some remedial conservation. Remedial conservation methods that can be employed include mechanical cleaning, desalination and electro plating. The study focused on the condition and conservation treatment of pewter objects which was informed by ICOM standards for museum collections. The study identified the condition and provided proper conservation practices for pewter and other metal objects found in the Oranjemund Shipwreck Collection. There is quite a lot of literature on pewter object conservation, but none specific to the Namibian context.

In daily use, pewter was kept bright and polished, and some collectors prefer this appearance. Pewter does not tarnish like silver, so a periodic clean with an all-purpose metal (not silver) polish will keep it looking bright. A lot of old pewter is patinated and has a colour ranging from mellow silver to charcoal grey - a more 'antique' appearance favoured by many collectors, especially in Britain and Europe (Poole 2013). It is possible to restore patinated pieces to a brighter and polished condition and there are degrees of restoration, depending on whether a completely untarnished appearance is preferred or whether some signs of age (e.g., oxidation in joints, dents, etc.) should be apparent. However, for archaeological finds it is recommended to at most polish one or two pieces to show what the original material could have looked like and leave the rest in their current state.

Oxidation on pewter varies according to the composition of the alloy and even this composition can vary on individual pieces. Serious oxidation can eat right through the metal and eventually creates holes, especially in sadware (dishes and chargers, for example). Expert guidance is needed if such pieces are to be restored. One reason for conserving objects is to prolong their life so that future generations can still enjoy them. This study agrees with Poole (2013) on the reasons for conserving rare objects when he states that in addition to desirability of maintaining the value of personal property, the owner of the antiquities possessing historical and cultural significance owes a very definite obligation to prosperity. The study recommends conservation regime activities that include examination, documentation, treatment, and preventive care, which is supported by research and education.

Conservation practice aims to prevent damage from occurring. This is called preventive conservation. The purpose of preventive conservation is to maintain, and where possible enhance, the condition of an object, as well as managing deterioration risks, such as handling and environmental conditions (Poole 2013).

It was revealed that the storage facility for the Oranjemund Shipwreck Collection has no controlled environment, despite having a humidifier and air conditioning equipment. The storage building has negative impacts on the preservation and conservation of underwater materials and the Oranjemund collection storage facility was found not to be in line with the international standards to be a permanent storage facility for this type of heritage. According to the ICOM'S code of ethics for museums/collections, every proper storage facility should have controlled environment, access to the collection, condition reporting and preventive conservation (ICOM Code of ethics for museum 2004). The pewter artefacts are stored in a dimly lit building with no temperature monitoring systems in place. The poor storage condition of the facility has had a negative effect on some of the pewter objects, as deterioration was clearly visible.

Poole (2013) states that proper atmospheric conditions for storage are one of the most important elements to consider in the care of pewter. He observed that below a temperature of about 16ºC, the basic constituent of pewter tends to lose its "metallic form" and tends to be converted to grey powder. These temperatures are not general in Oranjemund, but could occur. The publication does however not specify whether the humidity would have an effect.

A lack of skilled personnel has a negative impact on the condition of a collection. Staff members at Oranjemund Museum who handle the collection have received some basic training in handling of collections. One person received in-service training and the others received short-course training in the care of collections. It was found that the conservation department is under-staffed and this has affected the care of collections. Objects that require remedial conservation at Oranjemund continue to deteriorate unabated.

The third objective intended to analyse the corrosion products of the pewter plates with the intentions to assist the conservators to determine the best treatment for these objects (MacLeod 1991: 222).

The main corrosion product of pewter is white-grey lead carbonate, but due to the severe concretion and encrustation there is actually very little corrosion products visible. Where areas of the plates and other items were exposed, a typical grey-black patina of metal sulphides was observed. Without removing the objects from the collection and bringing it to an academic institution for analyses like X-ray Diffraction, it would be impossible to accurately identify specific corrosion products, as mentioned above. It is recommended that in future the staff at the Oranjemund Shipwreck Collection carry out this exercise to help them confirm stability of the objects and choose any appropriate conservation treatments.

5.2 Recommendations

One of the objectives of this study was “to make recommendation for the effective preservation, restoration and conservation of the pewter objects.” The following are the recommendations which emanate from the study findings:

- **Acquire proper storage facilities or move the whole consignment to Oranjemund town with a display section and market the significance of underwater heritage more.**

The researcher recommends that institution makes use of the necessary instruments to measure temperature and maintain it at the level needed for the well-being of underwater cultural heritage. The study has confirmed that the Oranjemund Shipwreck Collection receives fewer than 5 researchers per year. The current location of the collection has access challenges; it is housed in a storage facility within the Namdeb mine which demands an extensive permitting system, inductions and other clearances to enter the premises in order to reach the collection. Taking research equipment into the mining area is also problematic and limits the in-situ work that could be done. This makes visibility and thus awareness to the general public almost impossible.

Attempts should be made to develop brochures, a website, mobile exhibitions and documentaries to increase public awareness of the collection. A more long-term solution would be to move the collection away from the active mining area and establish a proper museum with displays where visitors can view and learn about the history of the collection. Now that Oranjemund town has been officially opened to the public and permits are no longer required to enter the town, building a mining and maritime museum could boost the town’s economy and increase the number of tourists and job opportunities. A museum in town will also enhance valuable research opportunities and the whole community will benefit from the conservation of this precious heritage. The best way to do this is to re-purpose an existing building in town, as building a new structure might be very costly for the National Museum of Namibia. A prospective building has been identified. This move will also give motivation to the employees as they will get the chance to interact with the community and visitors and have an improved working environment, instead of them sitting in what is seen as an abandoned, dusty building.

- **Training of conservators and hiring qualified staff**

The National Museum of Namibia should consider hiring qualified staff or up-skilling their own people. Their target could be newly graduated students from the University of Namibia who graduated with postgraduate diplomas in Heritage Conservation and management. They could also hire qualified conservators from neighbouring countries like Zimbabwe, South Africa and Botswana on a contract basis in order to train the existing staff members.

Phase two of the conservation of these objects, as well as current staffing shortages, can be addressed if a Memorandum of Understanding (MoU) is entered into between the National Museum of Namibia and the University Pretoria's (UP) department of Tangible Heritage Conservation. A number of students who are currently training in this department at UP can do their internships at the Oranjemund Shipwreck Collection. This will require limited resources and support. Research, workshops and consultations will be required if the museum is to emerge as a vibrant institution in the area of conservation, research, presentation and interpretation. The proposed MoU cited above is one way to kick-start this process.

- **Preventive Conservation**

Routine inspection of all the objects should be carried out on a six-monthly basis, as well as weekly routine inspections on the building itself, which in this case faces threats from sea wind, salts, as well as the humid environment. Because the environment around the building is always humid, there is a need for a double door system to minimize the effects of the outside environment on the artefacts. The building should be able to limit the amount of dust and smoke particles entering. They should also repair their air conditioning system and the humidity control.

5.3 Areas for further research

This study mainly focused on assessing and investigating the condition and possible conservation treatment of the pewter objects at the Oranjemund Shipwreck Collection. I realised that little was done in attempt to preserve the pewter objects from the Oranjemund collection. Thus, I recommend further research on identifying the maker's markings on these objects, confirming their provenance and to analyse the corrosion products to assist in choosing the appropriate conservation treatments.

5.4 Conclusion

This study has concluded that the National Museum of Namibia has no qualified conservators and because of that, their conservation department is not functional. Due to this most of the objects at the Oranjemund Shipwreck Collection are not cared for optimally. Apart from experience gained on the collection, staff members were never trained on preservation and conservation principles and only a few of them had the opportunity of some on-site training from experts in marine archaeology. The museum is planning on sending some staff members for qualifying training. There is some initiative to encourage students at the University of Namibia to study underwater archaeology and heritage management.

This study was devoted to assessing and investigating the condition and possible conservation treatment of the pewter objects at the Oranjemund Shipwreck Collection under the National Museum of Namibia. The specific objectives were to investigate the chemical composition and alloy characteristics of the pewter plates and to assess the conservation conditions of the pewter kitchen ware (i.e. current storage and environment). It also aimed to analyse the corrosion products of the pewter plates and to make recommendations for the effective preservation, restoration and conservation of the pewter objects at the Oranjemund Shipwreck Collection. This was a mixed method study using both qualitative and quantitative analyses and it made use of semi-structured interviews and XRF analysis as data collecting methods. The population of this study included staff members at the Oranjemund Shipwreck Collection and some of the pewter objects.

The collection of the pewter objects from the Oranjemund Shipwreck Collection is in a fair condition and presents a very simple class with no pieces of status or any decorations. Only a few have markings which are not quite visible and the origin of the flat ware remains a mystery, since the marking are untraceable at the moment of writing. With the wide range of compositions in different objects, one can assume that they are from different origins. However, I believe that it will be of great interest if we could trace the makers so that we can establish the provenance with certainty.

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Appendix A

Interview guide (staff members)

1. What is your position at this institution?

2. How long have you been working here?

3. Apart from your qualification and experience, have you ever received any other training on preservation and conservation of museum objects specifically underwater materials? If yes, how often, and how useful was it?

4. How often do you interact with these pewter materials?

5. How do you ensure safety for both you and the materials when in contact with the materials?

6. On average, how many users/visitors do you get per day?

7. How do you monitor and regulate the utilization of materials by the researchers with regard to the safety of materials?

8. Do you do any housekeeping? If yes; how often

9. What do you do to ensure that researchers and visitors do not damage the fragile artifacts?

10. What measures do you have in place to ensure that these materials are stored in the right conditions?

11. What type of storage facilities do you utilize and why?

12. Can you tell me the problems the museum faces regarding preservation and conservation of pewter objects?

13. Does the Oranjemund shipwreck/museum have any conservators? If no, what effect does this have on the institution? And is there something being done about it?